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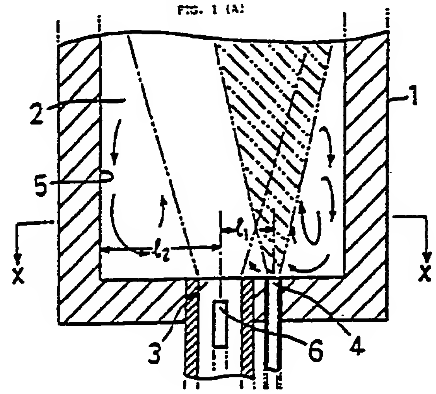
(54) A furnace combustion method.

(57) A furnace combustion method, comprising the provision of an air supply port and a fuel supply port respectively independently opened into a furnace with a distance kept between them and with a distance kept between said air supply port and the surrouding furnace wall, wherein combustion air and a fuel are injected respectively from said supply port and said fuel supply port into the furnace, for combustion with recirculation currents formed in the furnace.

FIG. 1 (A)



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A furnace combustion method

Detailed description of the invention

(Industrial field of application)

The present invention relates to a furnace combustion method for controlling nitrogen oxides (hereinafter called NOx) mainly used for industrial heating furnaces.

(Prior arts and problems)

Conventional combustion methods are described below based on Figs. 5 and 6. In Fig. 5, symbol a stands for a fuel supply portion; and b, an air supply portion. The fuel and air supplied as indicated by arrows from the respective supply portions a and b are mixed in a burner tile c, to burn and generate a flame. In this combustion method, since the area near the base of the flame highest in heat rate and also high in temperature is surrounded by a thermally insulating wall called burner tile c, radial heat dissipation does not occur, and a large volume of NOx is generated by the hot flame disadvantageously.

A combustion method actually applied to a glass melting furnace is shown in Fig. 6. In this furnace, an air supply portion b and a fuel supply portion a are opened into a furnace chamber d, but since there is little clearance between a glass surface 3 and the air supply portion b, gas recirculating currents are not formed in the furnace, and the air current flows along the glass surface 3. Since the fuel is directly injected into the air current, the gas in the furnace is not mixed with the fuel or air, and therefore the combustion at a low oxygen concentration does not occur, to inevitably raise the flame temperature. Thus, NOx emission level is naturally high disadvantageously.

(Object of the invention)

The object of the present invention is to decrease the NOx generated by the combustion of any fuel in any of various heating furnaces to a level lower than those achieved by conventional combustion methods.

(Means for solving the problems)

In order to explain the invention, reference being made to the accompanying drawing in which

Figs. 1 (A) and (B) are illustrative sectional views of a furnace to which the present invention method is applied. Fig. 1 (B) is a sectional view at X-X of Fig. 1 (A),

Figs. 2 are illustrations showing the relation between an air supply port and fuel supply port(s),

Fig. 3 is an illustration showing the location of adjacent air supply ports,

Fig. 4 is a NOx level diagram comparing the present invention with a conventional method,

Fig. 5 and 6 are illustrations of conventional burners.

In Figs. 1, symbol 1 stands for a furnace casing, and 2, the interior of the furnace. Into said furnace interior 2, an air supply port 3 and a fuel supply port 4 are opened respectively independently with a distance of ℓ_1 kept between them. Furthermore, between said air supply port 3 and a furnace inner wall 5, a distance of ℓ_2 is kept. In this structure, from said air supply port 3 and said fuel supply port 4, air and a fuel are injected into the furnace interior 2, for combustion while recirculating currents are formed as indicated by arrows in Fig. 1 (A). This corresponds to the combustion method stated in claim 1.

In the combustion method stated in claim 2, a fuel is injected from a low temperature fuel supply port 6 contained in the air supply port 3, for combustion while the temperature in the furnace interior 2 is lower than the ignition temperature of the fuel, for instance, lower than 750 °C, and the combustion method is switched to the combustion method stated in claim 1 when the temperature of the furnace interior 2 reaches the ignition temperature of the fuel, for instance, higher than 750 °C. In the structure stated in claim 3, as shown in Fig. 3, the same structure as stated in claim 1 or 2 is adopted except that plural air supply ports 3 are opened into the furnace interior 2, with a distance of ℓ_3 kept between the respective air supply ports 1.

In the structure of claim 4, plural fuel supply ports 4 are arranged around the air supply port 3 as shown in Figs. 2.

In Figs. 1, if air and a fuel are injected separately from the air supply port 3 and the fuel supply port 4 into the furnace interior 2, air and the fuel are not mixed directly, but mixed after they have been respectively mixed with the combustion gas in the furnace. As a result, combustion occurs at a low oxygen concentration, to achieve the effect of decreasing NOx. Furthermore, if the air and fuel injection method as stated above is used, the mixing is delayed compared with the mixing of air and fuel in a coaxial injection current as achieved by the conventional burner shown in Fig. 5, and as a result, slow combustion takes place, to provide a low temperature flame free from local high temperature. Also because of this, the effect of decreasing NOx can be achieved. Since the combustion in the present invention is as described above, the use of one air supply port 3 for one fuel supply port 4 generates a long flame which may be undesirable for some applications. In this case, if plural fuel supply ports 4 are provided as shown in Figs. 2, the fuel flow rate per fuel supply port 4 decreases, and the flame can be shortened. Even by injecting the fuel not in parallel to the air current, but at any angle against it, or by using a fuel supply port 4 with a radial nozzle at the tip, mixing state can be adjusted, to control the length of the flame. If the distance ℓ_2 is too short, sufficient recirculating currents cannot be formed in the furnace, and the object of the present invention cannot be achieved. For instance, it is preferable that ℓ_2 is not less than 1.5 times the diameter of the air supply port 3.

Moreover, depending on the shape and size of the furnace, it is necessary to provide plural air supply ports 3. In this case, if ℓ_3 is too short, the recirculating currents in the furnace interfere with each other. In this case, if ℓ_3 is not less than 2 times the diameter of the air supply port 3, the mutual interference can be prevented.

In the combustion method of the present invention, since air and a fuel are respectively mixed with the gas in the furnace before combustion, as described before, it is required to raise the temperature in the furnace upto the ignition temperature of the fuel gas by any proper means such as any temperature raising burner or ignition source at the start of operation. In the second version of the present invention, the low temperature fuel supply port 6 is provided in the air supply port 3. In this case, if the fuel is injected only from the low temperature fuel supply port 6 contained in the air supply port 3, for combustion, the mixing between air and the fuel starts as soon as the injection into the furnace interior 2 begins, and therefore, the combustion in the furnace takes place stably. Then, if the temperature in the furnace reaches a high temperature, for instance, higher than 750°C, the combustion can be changed into said regular combustion.

In the present invention, mixing and combustion start in the furnace interior 2 as described above. Therefore, the area near the base of the flame prone to high heat rate and high temperature is not surrounded by the thermally insulating wall, but exists in the space in the furnace. In the furnace interior 2, usually materials lower in temperature than the furnace inner wall 5 such as steel and molten metal exist to be heated. Therefore, as soon as the flame is generated in the space in the furnace, heat radiates to these low temperature materials, to lower the flame temperature. Also in this regard, the effect of lowering the NOx generation level can be achieved.

The following table shows the data obtained by using an experimental furnace shown in Fig. 1, together with the data obtained by the conventional methods. Fig. 4 shows the data of the following table in a diagram. The experimental conditions were as follows:

$L_1 = L_2 = 1000$ mm

$\ell_2 = 300$ mm

Fuel ... Natural gas

Firing rate .... 50×10^4 kcal/h

Air temperature ... 400°C

Air ratio ... 1.2

From the experimental data, it can be understood that the NOx could be remarkably decreased, compared with the conventional combustion method.

	conditions \ furnace temperature		1200	1250	1300	1300 ~ 1500
NOX	conventional combustion method		530	560	590	—
PPM	glass melting furnace		—	—	—	800 ~ 1200
O_2		l_1 = 0 (mm)	160	190	220	
0%	present	120	60	70	80	
NOx PPM	invention	220	65	60	70	
(in terms	combustion	320	45	50	60	
of 0% O_2)	method	420	50	50	60	

(Effects of the invention)

(1) Since air and a fuel are injected directly into the furnace with a distance kept between them and is then mixed, the mixing velocity is low, to cause slow combustion, and as a result, the flame temperature is lowered to generate less NOx.

(2) Since the distance between the air supply port nearest to the furnace inner wall and the furnace inner wall and the mutual distance between the air support ports are sufficiently long, recirculating currents of combustion gas are formed around the air and fuel supply ports, and before the combustion between air and the fuel starts, the combustion gas is mixed with air and the fuel. Therefore, the combustion occurs at a low oxygen partial pressure. This also lowers the flame temperature, to decrease NOx.

(3) Since the combustion starts and is completed in the furnace, the heat generation by combustion and the radiation to lower temperature materials take place concurrently to lower the flame temperature, for decreasing NOx.

Claims

(1) A furnace combustion method, comprising the provision of an air supply port and a fuel supply port respectively independently opened into a furnace with a distance kept between them and with a distance kept between said air supply port and the surrounding furnace wall, wherein combustion air and a fuel are injected respectively from said air supply port and said fuel supply port into the furnace, for combustion with recirculation currents formed in the furnace.

(2) A furnace combustion method, comprising the provision of an air supply port and a fuel supply port respectively independently opened into a furnace with a distance kept between them, with a distance kept between said air supply port and the surrounding furnace wall, and with a low temperature fuel supply port contained in said air supply port, in order that when the furnace temperature is lower than the ignition temperature of the fuel, combustion air may be injected from said air supply port while the fuel may be injected only from said low temperature fuel supply port, for combustion, and that when the furnace temperature has reached a temperature higher than the ignition temperature of the fuel, the supply of fuel from said low temperature fuel supply port may be stopped, while the fuel may be injected from the other fuel supply port, for combustion in the furnace with recirculating currents formed in the furnace.

(3) A furnace combustion method, according to claim 1 or 2, wherein plural air supply ports apart from each other are opened into the furnace.

(4) A furnace combustion method, according to claim 1 or 2, wherein plural fuel supply ports are arranged around the air supply port.

(5) A furnace for carrying out a method according to claim 1, comprising an air supply port and a fuel supply port respectively independently opened into a furnace with a distance kept between said air supply port and the surrouding furnace wall.

(6) A furnace according to claim 5, characterized in that it has a construction to carry out a method according to claims 2-4.

FIG. 1 (A)

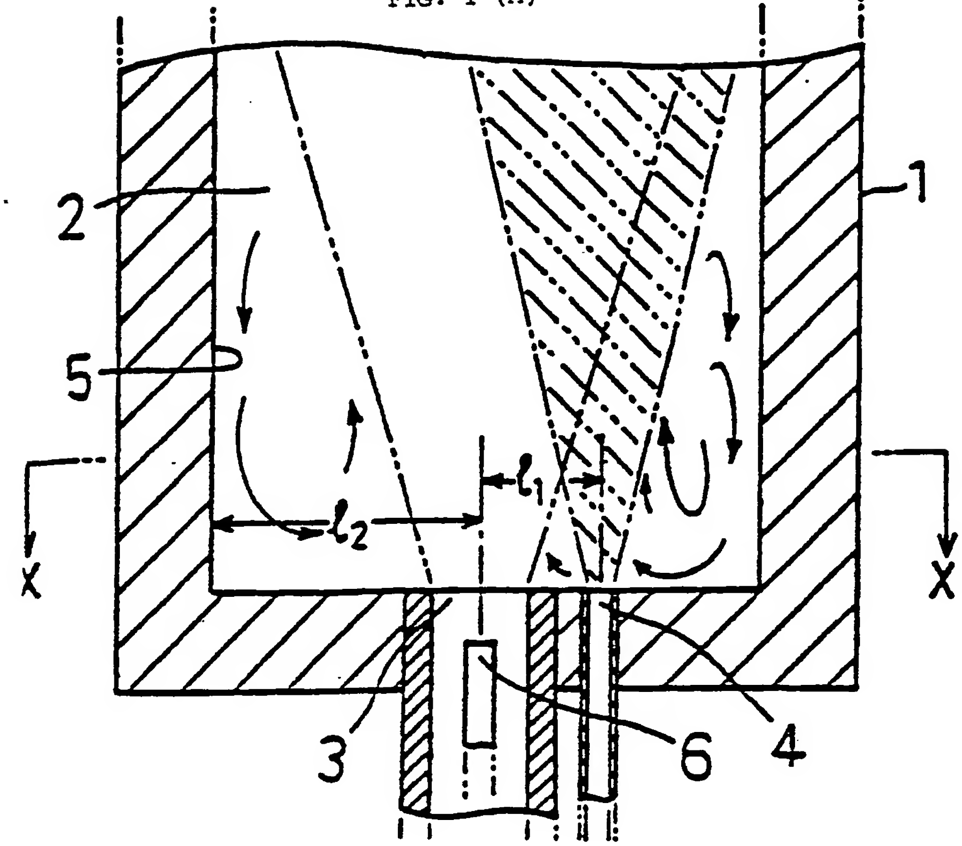

FIG. 2 (A)

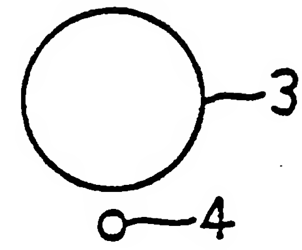

FIG. 2 (B)

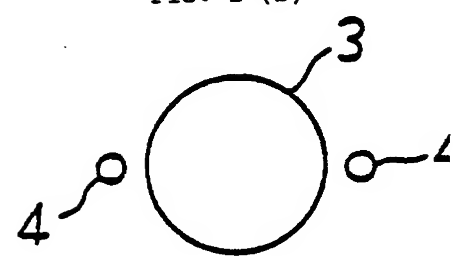

FIG. 1 (B)

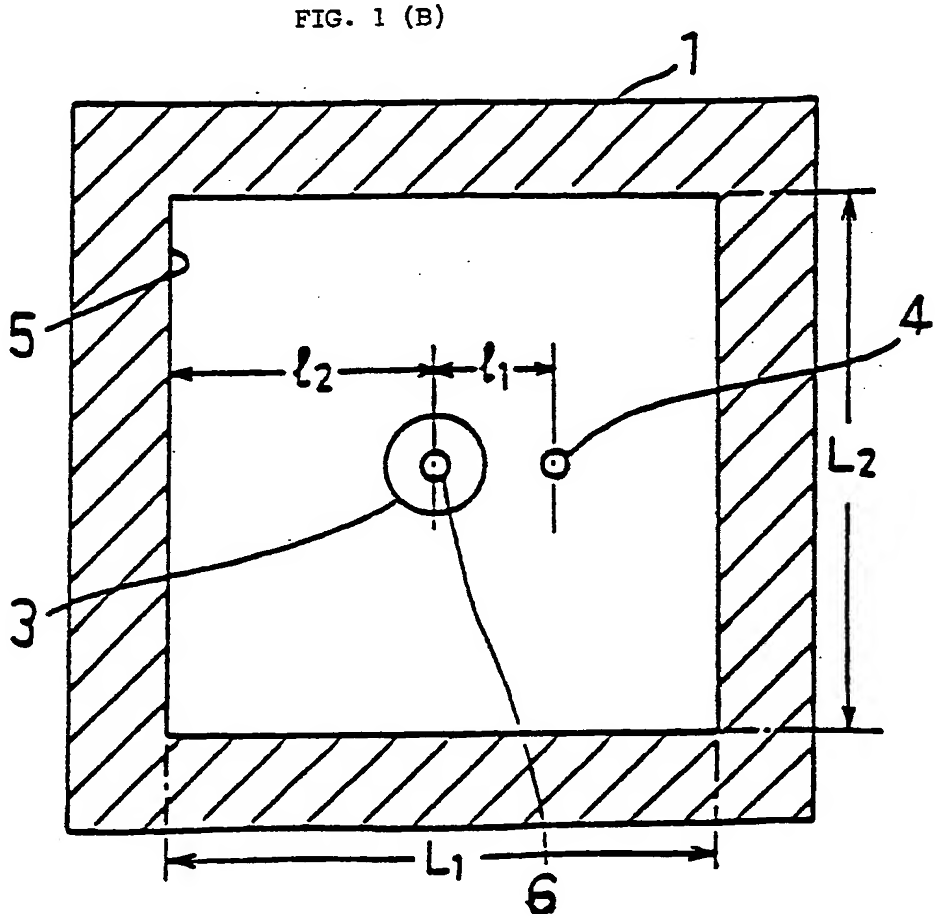

FIG. 2 (C)

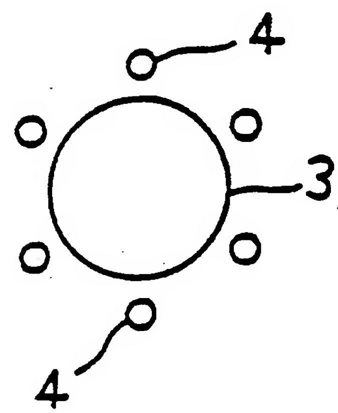

FIG. 3

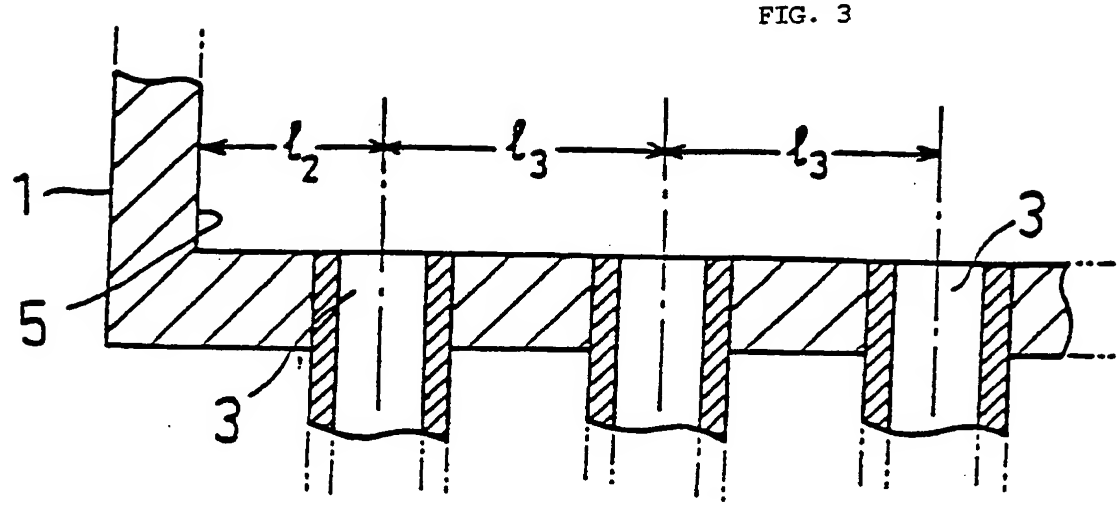
1
5
3
l_2
l_3
l_3
3

FIG. 4

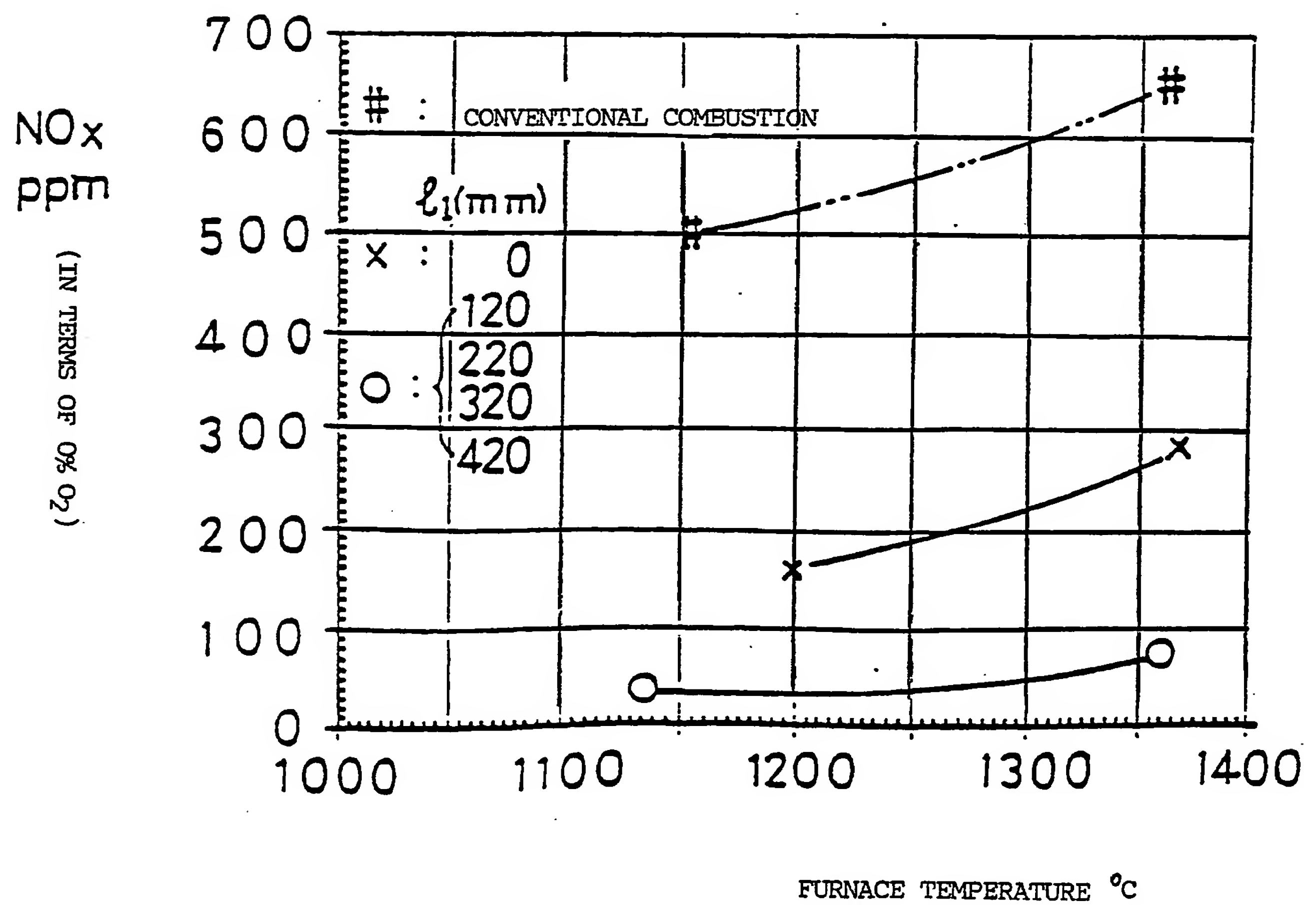
NOx
ppm
(IN TERMS OF 0% O2)
700
600
500
400
300
200
100
0
1000
1100
1200
1300
1400
# : CONVENTIONAL COMBUSTION
l1(mm)
× : 0
○ : 120
220
320
420
FURNACE TEMPERATURE °C

FIG. 5

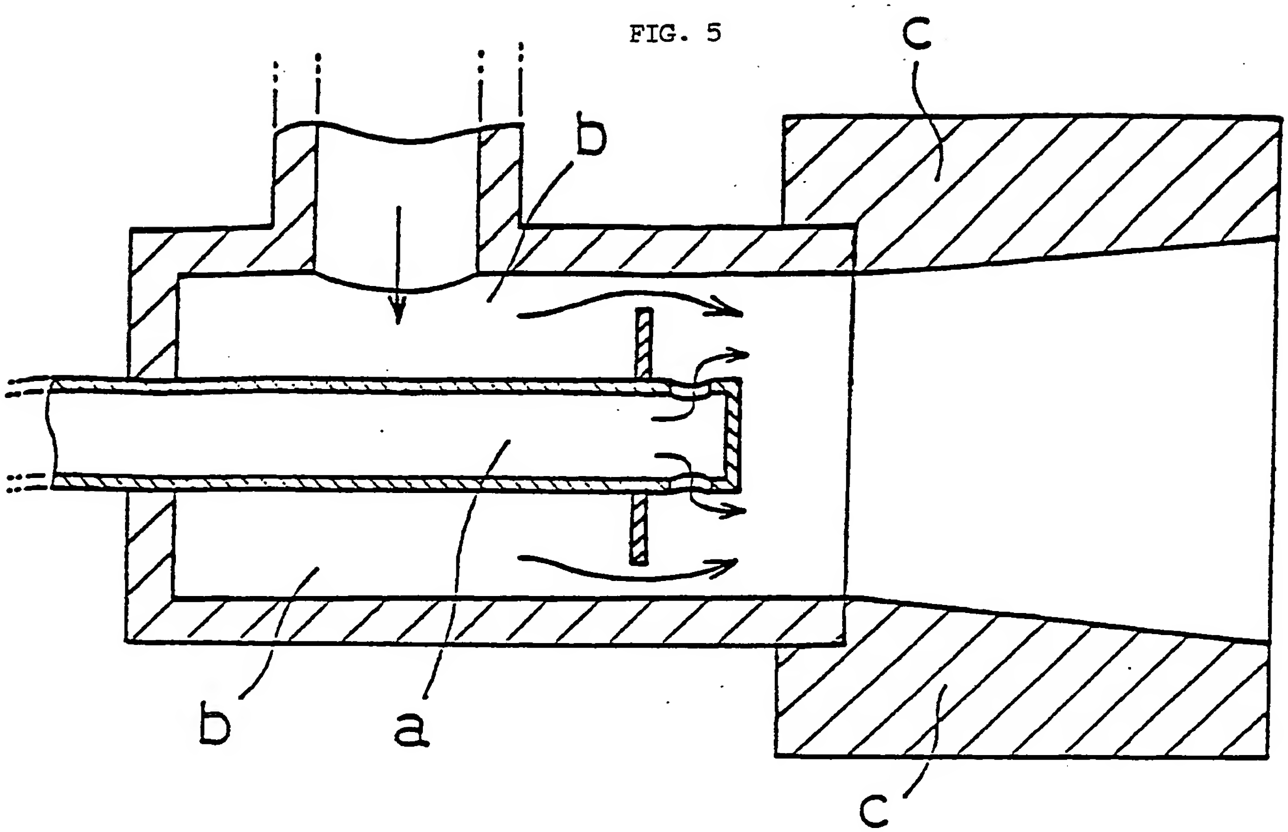

FIG. 6